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Marine security analysis and improvement measures based on PSC data of Tokyo MOU

Guan Zhang

WORLD MARITIME UNIVERSITY

Dalian, China

Marine Security Analysis and Improvement Measures based on PSC Data of Tokyo Mou

By

Zhang Guan

China

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): .....Zhang Guan.....

(Date): .....

Supervised by: Fu Yuhui

Professor

Dalian Maritime University

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Abstract

Since the implementation of PSC inspection, it has been playing a significant role in fighting against substandard ships, protecting marine environment and enhancing shipping efficiency. With the progress of PSC inspection, an increasing number of countries joined the regional memorandum organizations and paid more attention to PSC inspection. At present, in order to analyze ship's security more accurately, the majority of PSC memorandum organizations have established evaluation system of flag state's performance, aiming to supervise flag state to perform international conventions effectively and reinforce safety management of ships flying its flag, of which one of the most influential is flag state 'BGW' list regime adopted by Paris Mou and Tokyo Mou.

PSC inspection results could reflect security status of flag state's ships, so this paper carries out objective analysis on flag state's performance through analysis of PSC inspection data and existing evaluation system of flag state's performance. This paper firstly introduces relevant concepts of flag state's performance and PSC, as well as relationship between the both, analyzes Tokyo Mou's PSC inspection data of recent 3 years in 2012-2014, and then analyzes drawbacks of existing flag state 'BGW' list regime: lack of historical inspection data of other regional memorandum organizations, only applicable to flag states that are subject to more inspections, and

lack of maritime traffic accident factor. In view of above drawbacks, this paper objectively evaluates flag state's performance and data verification with utilization of integration of PSC inspection data of various regional memorandum organizations, application of Bayes theorem and augment of maritime traffic accident factor respectively. In the end, author puts forward some suggestions and measures to improve flag state's performance from perspectives of flag state, port state, shipping company, etc., in line with status quo of flag state's performance and PSC.

KEYWORDS: Port state control, Flag state performance, Tokyo Mou, 'Black-Grey-White' list, Evaluation, Countermeasures

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LIST OF ABBREVIATIONS

APCIS	Asia Pacific Computerized Information System
'BGW' list	'Black-Grey-White' list
CIC	Concentrated Inspection Campaign
DP	Designated Person
EF	Excess Factor
FOC	Flag of Convenience
FSI	Flag State Implementation
FSC	Flag State Control
FSQCS	Flag State Quality Management System
GT	Gross Tonnage
IMO	International Maritime Organization
ISM	International Safety Management
ISPS Code	International Ship and Port Facility Security Code
LR	Lloyd's Register of Shipping
NIR	New Inspection Regime
PSC	Port State Control
Paris Mou	Paris Memorandum of Understanding
QMS	Quality Management System
R.O.	Recognized Organization
SMS	Safety Management System
Tokyo Mou	Tokyo Memorandum of Understanding
UNCLOS	United Nations Convention on the Law of the Sea
USCG	United States Coast Guard
VIMSA	Voluntary IMO Member State Audit
VIMSAS	Voluntary IMO Member State Audit System

Chapter 1 Introduction

1.1 Background and objective of the research paper

For a long time, shipping industry mainly depends on the flag state's general supervision on ships flying its flag concerning implementation of international standard of maritime security and preventing ships' pollution to marine environment. However, on the one hand, since open ship registration regime prevails, flag state's management mechanism has been hard to satisfy expected aim; on the other hand, flag states increasingly rely on R.O. to implement safety technique standards promulgated by the IMO and to carry out ships' statutory survey and certification. Since the 1980s, frequent marine accidents have caused serious damage to the human life safety and marine environment, which have attracted great attention from the IMO and port state authorities. Therefore, the IMO put forward triple responsibility of implementation of standards: the IMO is responsible for setting standard; the flag states are responsible for implementing standards; the port states are responsible for supervising and inspecting on implementation of standards, with aim to eliminate substandard ships out of shipping market(Wang et al, 2009).

At present, PSC is universally acknowledged as an effective action by international community in terms of eliminating substandard ships, safeguarding ship's navigation safety, preventing ships' pollution to marine environment and promoting flag state's performance. Ships of more than 20 years old are hard to find in developed countries such as Singapore, Switzerland, which improves regional safety level of marine safety and environment. In India, a developing country, maritime authorities have the right to limit old ships into jurisdictional water area, but some less developed countries such as Liberia become FOC, whose marine safety management level is

low, which gives rise to great hidden danger to navigation safety and marine environment(Shi, 2012).

Article 94 in UNCLOS stipulates that flag states should undertake obligation on ships flying their flag, namely the flag states should take measures to ensure marine safety performance and manning comply with the provisions of relevant domestic laws and regulations of international maritime conventions(Yao, 2008). As to ships engaged in international voyage, flag states have primary supervision liability for ships flying their flag, and the PSC inspection results reflect safety management situation of ships to some extent, which further measures one state's marine safety management level and performance capacity.

Currently, most of PSC memorandum organizations have established their own evaluation system of flag state's performance. The most influential one is flag state 'BGW' list regime adopted by Paris Mou and Tokyo Mou, and the regime divides flag states into 'BGW' list according to the different security risk of flag states' fleet or different ships' detention rate in recent 3 years.

However, in recent years, the 'BGW' list regime has been questioned by international community and some flag states. Firstly, because each regional PSC memorandum organization does things in its own way, individual flag state's performance is good in some regional memorandum organization and ranked 'White' list, but another memorandum organization divides it into 'Black' list. Secondly, current 'BGW' list regime only applies to flag states of which ships are subject to more than 30 inspections in recent 3 years, but as to flag states less than 30 inspections, the memorandum organizations do not evaluate their performance. Consequently, several flag states' ships have low inspection frequency but very high detention rate, and

they could escape punishment of ‘Black’ list. Thirdly, current ‘BGW’ list regime only considers PSC factor, ignoring maritime traffic accident factor, without justice and equity. For all the above reasons, we need to objectively analyze and evaluate flag state’s performance and improve flag state’s performance from all angles.

1.2 Research status

As effective supplement of flag states and ‘last line of defense’ for safeguarding ships’ navigation safety and preventing marine environmental pollution, the concern extent of PSC inspection from international community rises increasingly, and becomes hot topic of international research. Numerous document literature provides important references for this research paper. International document literature concentrate mainly on 3 aspects. First aspect is research on relevancy between PSC and maritime traffic accidents, for example, professor Sabine Knapp and professor Philip Hans Franses’s research with the tittle of ‘Econometric analysis on the effect of port state control inspections on the probability of casualty’ in 2006. It demonstrated that every PSC inspection could reduce approximately 5% possibility of serious accident through calculations(Knapp, 2007); Maria Hanninen and Pentti Kujala used Bayesian network modeling to conduct statistic analysis on PSC inspection results and marine accident, and studied the relationship between the two parts(Hanninen, 2014). Second aspect is research on PSC targeting regime, for example, scholar Pierre Carious, Maximo, etc. on basis of technical data model, compared poison distribution, negative binomial distribution and other results, and showed 3 key factors that decide deficiency number in PSC inspections: vessel age, flag states and ships type(Carious, 2009). Third aspect is evaluation methodology in terms of improving flag state’s performance. For example, Mikhail Perepelkin and other people, with the tittle of ‘An improved methodology to measure flag

performance for the shipping industry', carried out research on consideration of maritime traffic accident factors in evaluation of flag states' performance, and proposed evaluation methodology of flag states' performance based on Wilson score interval(Perepelkin et al, 2010); Fan(2014) and other people analyzed the determinants of flag-out decisions and PSC inspection rates, taking into account the reciprocal impact of a ship operator's flag-out decision and the PSC's inspection rate.

Domestic literature mainly focuses on research of ship safety management. Wu(2002) adopted combinative methodology between identification and quantification to establish mathematical modeling with utilization of comprehensive analytic hierarchy process and fuzzy comprehensive evaluation, and conducted research on detention decision problem of ships' safety inspection. Zhong(2011) elicited incidence of each deficiency factor in PSC to marine accident by factor analysis method, and estimated marine safety condition according to importance degree of deficiency factor. Leng(2014) clustered and analyzed PSC inspection data, and discussed inner link of inspection relults and measured flag states' marine safety management level.

To sum up, domestic scholars have not carried out research on evaluation of flag state performance and marine security analysis, and international research is also very little. Considering malpractice of current evaluation of flag state performance, more fair and more scientific evaluation of flag state performance is urgent and related research work is imperative.

1.3 Main content of the research paper

This research paper is divided into 7 chapters. The first chapter sets forth background

and objective of this research, and research status domestic and overseas and framework of this research paper; the second chapter introduces related concepts: flag state's responsibility and flag states' performance, and PSC's purpose, significance and procedure, analyzes relationship between flag states' performance and PSC; the third chapter analyzes PSC inspection situation and development trend of Tokyo Mou; the fourth chapter introduces current 'BGW' list regime, and analyzes existing drawback of 'BGW' list regime; the fifth chapter evaluates flag states' performance including integration of inspection data from every PSC memorandum organization, utilization of Bayes theorem and addition of maritime traffic accident in evaluation; the sixth chapter puts forward improvement measures of flag states' performance in terms of flag state, port state, R.O., etc.; the seventh chapter summarizes this research paper.

Chapter 2 Flag state performance and Port state control inspection

2.1 Flag state performance

2.1.1 Obligation of Flag state

The flag state of a commercial vessel refers to the state under whose laws the vessel is registered or licensed. The reason why the ships flying flag is for avoiding being mistaken for a smuggler or a pirate ship and protecting various countries' territorial sea at the same time(Xue, 2006, pp651).

Article 94 in UNCLOS 1982 (Duties of the flag state) explicitly stipulates the flag state's obligations over ships flying its flag. *Each flag state shall effectively exercise its jurisdiction and control in administrative, and technical and social matters over ships flying its flag. Each flag state shall assume jurisdiction under its internal law over each ship flying its flag and its master, officers and crew in respect of administrative, technical and social matters concerning the ship. Each flag state shall take such measures for ships flying its flag as are necessary to ensure safety at sea with regard to: the construction, equipment and seaworthiness of ships; the manning of ships, labor conditions and the training of crews, taking into account the applicable international instruments; the use of signals, the maintenance of communications and the prevention of collisions. When taking the above measures, each flag state is required to conform to generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance.*(United Nations Conference on the Law of the Sea (1982))

In the aspect of marine environment protection, Article 217 in UNCLOS prescribes

flag states' assumed obligations. *Flag states shall ensure compliance by vessels flying their flag or of their registry with applicable international rules and standards, established through the competent international organization or general diplomatic conference, and with their laws and regulations adopted in accordance with this convention for the prevention, reduction and control of pollution of the marine environment from vessels and shall accordingly adopt laws and regulations and take other measures necessary for their implementation. If ships can not comply with these standards, the flag state should prohibit the ships from sailing. Flag states shall ensure that vessels flying their flag carry on board certificates required by and issued pursuant to international rules and standards.* (United Nations Conference on the Law of the Sea (1982))

2.1.2 Flag state performance and existing problems

The UNCLOS has confirmed responsibility of flag state, and shipping community mainly rely on flag states' supervision on ships flying their flag performing international conventions in terms of maritime safety and preventing marine environmental pollution from ships all the time. Additionally, flag state's performance is also identified as the first line of defense with objective of 'safe, reliable and effective navigation on clean ocean'(Jiao, 2013). However, there are many loopholes in eliminating substandard ships under current flag state's performance, which make the flag state fail to exercise its functions effectively. It is demonstrated by the following aspects:

2.1.2.1 FOC system

Many ships conduct registration in countries that have loose registration, obtain the

country’s nationality, and fly the country’s flag to reduce operating costs or avoid the regulations of the owner's country(Egiyan, 1990). The reason why part of the countries and regions turn into FOC countries and regions is collecting shipping register and related expenses. Most FOC countries and regions have no ability to implement effective safety management over ships flying their flag. Subjectively, these countries are also unwilling to manage the ships under administrative, technical and social matters, which greatly reduce operating costs of the vessel, so that they are on a good wicket in international shipping competition(Li, 2007). In addition, due to political factors, in order to avoid conflict with hostile countries, some ship owners also often join their ships into FOC(Lu, 2009, p44-47). However, drawbacks of FOC regime are obvious. Specifically, flag states lack effective supervision on ships flying their flag, some ship owners from FOC reduce marine maintenance and crew business training for dropping operating costs, which constitutes serious menace on ship safety and marine environment. Furthermore, because FOC countries generally lack effective maritime legislation, some countries even do not join relevant international convention, meanwhile are unwilling to perform commitment set forth by international convention subjectively. Therefore, accident rate of ships in FOC generally exceeds other ships in regular registration. According to the data from LR, globally the number of ships in FOC accounts for 1/3 of world fleet approximately, but the accident rate occupies more than 1/2(Zhang, 2008).

2.1.2.2 Classification society

Because development history of classification society and classification society rules precedes development of IMO and international maritime conventions, therefore, maritime community generally accepts classification society rules, and executes code standard of classification society in ship’s construction requirement in terms of

structure and machinery and so forth(Boisson, 1994). But in recent years, due to deficiencies reflected by some marine accidents in marine structure, a few of member states in IMO have concentrated query of flag state's performance on functions of classification society. Most flag states' maritime authorities mainly depend on classification society to ensure ships flying their flag perform international maritime conventions, but the question is that not every classification society executes the same strict ship's classification system(Geng, 2004). A number of ship owners give up those strict classification societies, but go into those classification societies with loose standard. Some classification societies bring down ship classification survey standard under the pressure of market competitions. If things continue this way, the whole ship's classification standard could be reduced, and then the consequence is bringing about serious marine accidents.

2.1.2.3 International convention

Mainstay of flag state's performance is international convention, and contracting states have rights and responsibility for the supervision and administration on ships flying their flag. However, international conventions experience a long time in most cases from formulation to enforcement, a number of conventions even have formulated time, but no entry-into-force time. Time difference of international convention between formulation and enforcement urges a great many countries to consider that there is no need for signing an international convention to wait for contracting states' entire actions on many matters, and adopting unilateral action or regional combined action may be more realistic.

2.1.3 Current evaluation system of Flag state performance

In order to improve status quo of flag state's performance in global range and promote flag state to effectively perform assumed legal functions, most of PSC memorandum organizations and countries have established evaluation system of flag state's performance.

Paris Mou and Tokyo Mou have implemented flag state's 'BGW' list regime that divides flag states into 'Black list', 'Gray list' and 'White list' according to performance of ships flying their flag in PSC inspection in recent 3 years. Flag states with high risk are rated 'Black list'; flag states with low risk are rated 'Gray list'; while the best flag states are rated 'White list'. 'BGW' list is published once a year, if the flag state within 'Black list', risk rating of its fleet would increase accordingly, and would be subject to more frequent and strict inspections.

The USCG announces the rolling detention rate of each flag state for recent 3 years in annual report, if the rolling detention rate of some flag state exceeds average detention rate, then risk factor value of its fleet would increase and ships flying its flag would be subject to inspection with priority level. Moreover, one of the significant evaluated conditions of USCG's 'QUAL SHIP' is that detention rate of flag state's ships have to be inferior to average detention rate of previous 3 years, arrival number of ships registered in flag states is not less than 10 annually in previous 3 years, and the flag states should pass the VIMSA(Ma, 2007).

Thus it can be seen that the flag state's performance has significant influence on interests of its fleet, therefore, each flag state hopes that ships flying its flag have good performance in PSC inspections in order to keep good reputation and image, on the other hand to attract more ship naturalization(CNSS expert column, 2012).

2.2 Port state control

2.2.1 Objective and significance of Port state control

The main purpose of PSC inspection is to decrease the number of substandard ships and to ensure ship's safe navigation and protect marine environment. Substandard ships refer to the ships with standard of hull, machine, equipments or operational safety substantially below the standard required by the relevant conventions or actual manning not conforming to the safe manning document(Lowe, 1982). Nowadays, the PSC has been not only for controlling substandard ships, but also has become effective measures for improving ships' safety level.

International organizations such as IMO and ILO have established a series of conventions to guarantee ship safety operation, and these conventions not only rely on the efforts of flag states to ensure their implementation, but also need port states' supervision and control. Each flag state carries out inspection on ships flying its flag in the light of requirements of flag state and relevant international conventions, corrects and eliminates the inspected ships' deficiencies, which is the first line of defense of ship safety. But because of different economic development level, recognition level as well as inspection standard of various flag states, hidden danger exists marine security. Therefore, PSC inspection could improve ship's operation condition, maintain maritime safety, prevent environmental pollution and protect self-interest of each port state. In addition, PSC inspection would be of great importance in promoting uniform international standard and enhancing regional cooperation, and the practice has proved that PSC is the most effective measure to decrease the number of substandard ships. IMO specially set up the FSI sub-committee to supervise executive condition of each contracting state's

performance, simultaneously feedback condition to IMO via PSC inspection. PSC inspection attaches great importance of flag states' authorities and ship owners, and vastly boosts ships' security status.

On basis of data of Tokyo Mou annual report, Figure 1 shows PSC inspection condition in 2004-2014. As we can see from figure 1, the total inspection number shows an increasing trend over the years, which indicates most countries pay increasing attention to PSC inspection. The number of member states in Tokyo Mou increased to 19 in 2014 from 12 in 1992, and available resources of PSC inspection also increase(Tokyo Mou web site). Figure 2 is percentage changes of detention number, through observation, we can see detention percentage falls down year by year, which speaks volumes for outstanding effect of PSC inspection in terms of enhancing ship's safety level and reducing hidden accident trouble.

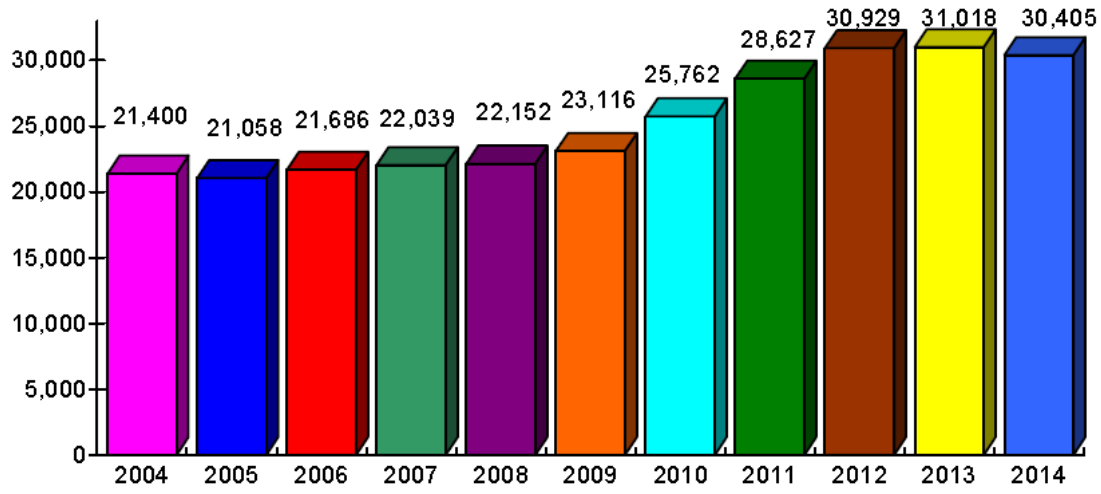

Figure 1 – Number of inspection
Source: Annual report on PSC in the Asia-Pacific region 2014

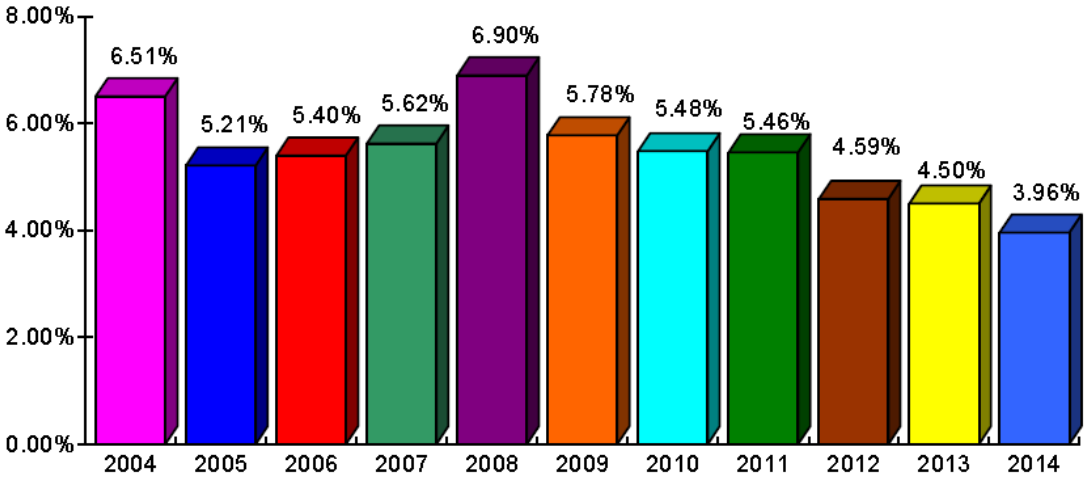

Figure 2 – Number of inspection with detention percentage
Source: Annual report on PSC in the Asia-Pacific region 2014

2.2.2 Port state control procedure

On November 30, 2011, the ninth agenda of the 27th assembly in IMO adopted A.1052(27) of 'Procedures for port state control, 2011' that submits each contracting state government to implement this procedure while carrying out PSC.(Procedures for Port State Control (2011)) This procedure belongs to the second procedure related to PSC implementation since the establishment of global PSC regional organization, the issue of which has great influence on PSCO's standard of behavior and ship's daily operation. The procedure is not only observed by PSCO while carrying out inspection, with regard to master's deeper understanding on the procedure, but also used to guide ships' daily management. The proficient utilization of the procedure could alter possible unfavorable situation during PSC inspection.

2.3 Relationship between Flag state performance and Port state control

The flag states assume primary legal liability to eliminate the substandard ships, and

formulation and performance of international conventions on the basis of flag states' safety management. Therefore, flag states' performance is the most significant means in executing conventions, and PSC is considered as assistance and supplement of flag states' performance. It is the flag states' performance that has numerous loopholes in eliminating substandard ships, which further gives rise to PSC, and practice has proved that PSC could effectively control substandard ships.

2.3.1 Port state control is supplement of Flag state performance

IMO resolution A.1052(27) explicitly mentions that PSC procedure should be seen as a supplement of FSC, with the objective of helping flag states to advance their ships' quality(Procedures for Port State Control (2011)). However, flag state's inspection on its fleet's quality condition could not completely rely on PSC, because PSC has some limitations essentially. For example, the relevant international conventions explicitly stipulate that PSC can not cause ship's undue delay, otherwise the ships have right to claim for compensation, which determines the PSC has certain limitations with regard to inspection time and inspection scope, and cannot carry out detailed inspection on ships regularly like flag state inspection. So flag state is primary part in charge all the time, and PSC is only supplement of flag state's performance.

2.3.2 Effective Flag state performance contributes to Port state control

The global shipping industry generally accepts that if all of the flag states could fulfill their duties effectively, and ensure their ships comply with the minimum safety standards stipulated in international conventions, then the PSC is not necessary. With the implementation of VIMSAS in recent years, performance level of global flag states improves continually, and PSC could concentrate limited resources on fighting

against minority substandard ships with pertinence, which greatly enhances efficiency of PSC inspection. With respect to PSC, efficient performance level of flag state would not only contribute to enhancing its fleet quality, but also provide abundant human resources for the state carrying out PSC. Former chairman Ms.T.Krilic of FSI in IMO pointed out that it is hard to believe that a flag state without full fulfillment of its responsibility has satisfactory PSC level(Krilic, 2007).

Chapter 3 Analysis on Tokyo Mou PSC inspection

It has been 20 years since the establishment of Tokyo Mou. During this period, the member states of Tokyo Mou positively participated in PSC inspection. By December 31, 2014, as database in statistical information of Tokyo Mou shows, the Tokyo Mou had totally conducted 436776 ship inspections, detaining 20445 ships(Tokyo Mou web site), which effectively enhanced ships' security situation. This chapter introduces PSC inspection situation in line with PSC inspection data of Tokyo Mou.

3.1 Comparative analysis of inspection condition of recent 3 years

3.1.1 Good development trend

Tokyo Mou 2014 annual report worked out specific exposition to PSC inspection results and correlated activation carried out. Based on the data and information, it can be seen that overall development of PSC in Tokyo Mou is good, but a few serious deficiencies still exist. In 2014, due to the implementation of the NIR, PSC inspection in Tokyo Mou possess pertinence, the inspection number decreased by 613 ships compared to that in 2013, detention rate assumes declining situation year by year. Like 2013, general cargo vessel and bulk carrier are the two most frequently inspected ship types, and fire safety, navigation safety and life saving appliances are still the 3 prominent deficiencies in inspection. Compared with 2012 and 2013, deficiencies in 2014 in aspects of certification and document, labor conditions and MARPOL III & IV increase greatly(Tokyo Mou, 2014), which should be paid special attention to.

3.1.2 Launch of CIC

Launch of CIC could utilize PSC inspection resources of each memorandum, timely discover and rectify deficiencies, raise the safety and pollution prevention awareness of shipping companies and crew, and improve performance condition of ships. From September 1 to November 30, 2014, the CIC concerning STCW hours of rest jointly carried out by the Tokyo Mou and Paris Mou, discovered 1589 deficiencies with respect to hours of crew rest, most of which relate to hours of rest not being recorded correctly, accounting for 63%(Tokyo Mou Secretariat, 2015). Discovery of a large number of deficiencies had warning effect for ship owners and crew, thus to some extent reduce fatigue and insufficient rest of watch-keeping personnel.

3.1.3 Paying more attention to human element in inspection

PSC inspection results, to a large extent, depend on PSCO's subjective judgment, therefore, PSCO's professional quality plays a critical role during the whole inspection. As early as 2004, secretary joint conference of Tokyo-Paris Mou particularly emphasized significance of PSCO's individual behavior, only optimum behavioral expression of PSCO at work could ensure the final purpose of PSC inspection(Xiao, 2004, p7). As a result, after the Paris Mou, the Tokyo Mou adopted 'Code of Good Practice for Port State Control Officers Conducting Inspection within the Framework of Tokyo Mou', and included it into 'Asia-Pacific Port State Control Manual' and required all the PSCO to strictly observe relevant provisions in inspections.(Tokyo Mou, 2009)

3.2 Inspection situation of member states and flag states inspected

3.2.1 Inspection situation of member states

Taking inspection data in 2014 as an example, as shown in table 1, according to statistical data in APCIS, member states carried out initial PSC inspections on 30405 ships in 2014, of which 19079 ships were found with deficiencies, 11326 ships passed inspection without deficiency, 1208 ships were detained, with the detention rate of 3.97%. In 19 member states, inspection condition of each member state is shown as figure 3, inspection numbers of China, Japan and Australia were in the top three, which inspected a total of 1644 ships, accounting for 54.07% of the overall inspections.

Table 1 – Port state control inspection condition table in 2014

Code	Authority	No. of inspections	No. of inspections with deficiencies	No. of deficiencies	No. of detentions	Detention percentage
AU	Australia	3742	2357	10892	269	7.19 %
CA	Canada	389	200	721	5	1.29 %
CL	Chile	901	430	1196	26	2.89 %
CN	China	7361	6189	33768	481	6.53 %
FJ	Fiji	2	0	0	0	0.00 %
HK	Hong Kong, China	736	667	3415	47	6.39 %
ID	Indonesia	2605	570	2172	24	0.92 %
JP	Japan	5337	3545	17839	208	3.90 %
KR	Korea, Republic of	1928	1299	5310	73	3.79 %
MY	Malaysia	918	380	1357	9	0.98 %
MH	Marshall Islands	21	14	91	1	4.76 %
NZ	New Zealand	239	139	626	9	3.77 %
PG	Papua New Guinea	124	53	201	4	3.23 %
PE	Peru	0	0	0	0	0.00 %
PH	Philippines	2016	535	1450	2	0.10 %
RU	Russian Federation	996	759	4016	13	1.31 %
SG	Singapore	1127	856	4079	28	2.48 %
TH	Thailand	566	144	354	0	0.00 %
VU	Vanuatu	0	0	0	0	0.00 %
VN	Vietnam	1397	942	3688	9	0.64 %
	TOTAL:	30405	19079	91175	1208	3.97 %

Source: https://apcis.tmou.org/

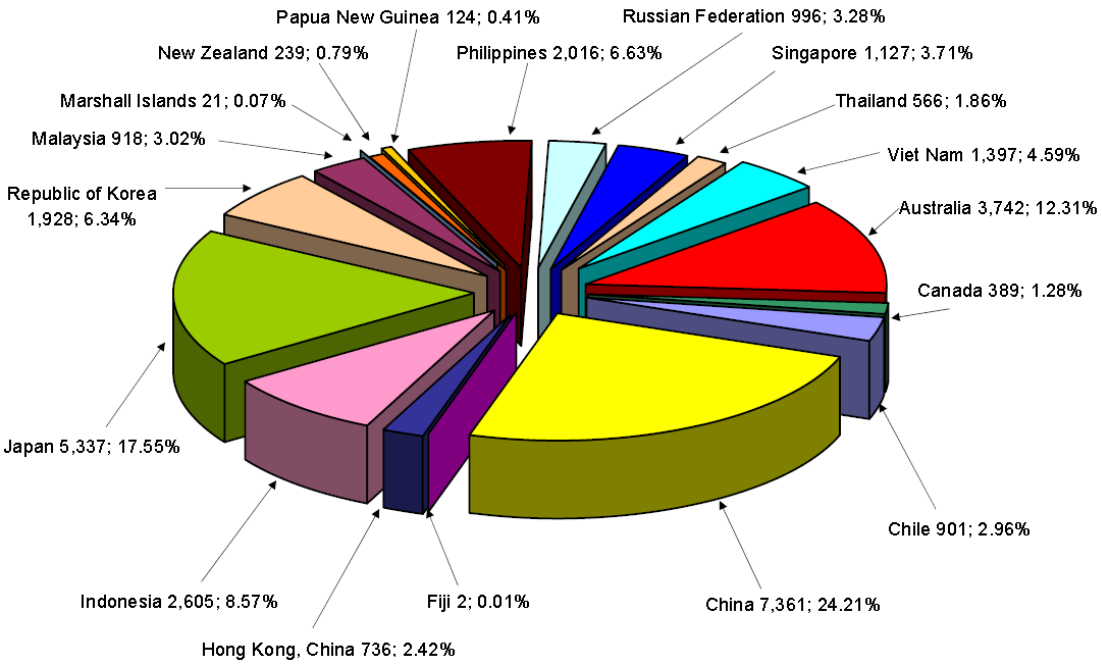

Figure 3 – Contribution of PSC inspections by authorities
Source: Annual report on PSC in the Asia-Pacific region 2014

Table 2 is PSC inspection condition implemented by member states. On the basis of statistic data, it can be seen that Australian PSC inspection rate was the highest in 2014, reaching 56.75%. It is interesting to note that the number of foreign ships arriving at Singapore port was 12874, but the inspection rate of Singapore was only 7.43%, which was relatively low. Because ships have many calling ports and are inspected repeatedly, a total of 16761 ships were inspected by PSC in 2014, 24128 ships arrived at member states' ports, and the regional PSC inspection rate was 69%.

Table 2 – Port state inspections carried out by authorities

Authority	No. of individual ships inspected (a)	No. of initial and follow-up inspections (b+c)	No. of initial inspections (b)	No. of follow-up inspections (c)	No. of inspections with deficiencies (d)	No. of deficiencies [1] (e)	No. of detentions [1] (f)	No. of individual ships visited [2] (g)	Inspection rate (a/g%)	Detention percentage (f/b%)
Australia[3]	3,267	5,631	3,742	1,889	2,357	10,886	269	5,757	56.75	7.19
Canada[4]	387	389	389	0	200	720	5	1,898	20.39	1.29
Chile	820	1,272	901	371	428	1,169	26	1,718	47.73	2.89
China	5,792	8,658	7,361	1,297	6,180	33,195	476	14,980	38.66	6.47
Fiji	2	2	2	0	0	0	0	219	0.91	0
Hong Kong, China	722	787	736	51	662	3,327	47	5,035	14.34	6.39
Indonesia	2,205	2,816	2,605	211	570	2,148	24	6,489	33.98	0.92
Japan	3,522	6,475	5,337	1,138	3,538	17,434	208	7,374	47.76	3.90
Republic of Korea	1,633	2,542	1,928	614	1,287	5,094	73	9,637	16.95	3.79
Malaysia	768	1,055	918	137	375	1,317	9	6,385	12.03	0.98
Marshall Islands	20	31	21	10	14	90	1	100	20.00	4.76
New Zealand	204	335	239	96	139	620	9	941	21.68	3.77
Papua New Guinea	103	174	124	50	53	196	4	309	33.33	3.23
Philippines	1,516	2,468	2,016	452	533	1,434	2	2,929	51.76	0.10
Russian Federation[4]	719	1,885	996	889	758	3,960	13	2,488	28.90	1.31
Singapore	957	1,468	1,127	341	853	4,019	28	12,874	7.43	2.48
Thailand	455	658	566	92	141	343	0	3,598	12.65	0
Vanuatu	0	0	0	0	0	0	0	45	0	0
Viet Nam	1,084	1,868	1,397	471	941	3,608	9	2,681	40.43	0.64
Total	**16,761**	**38,514**	**30,405**	**8,109**	**19,029**	**89,560**	**1,203**	**Regional 24,128**	**Regional 69%**	**Regional 3.96%**

Source: Annual report on PSC in the Asia-Pacific region 2014

3.2.2 Inspected situation of Flag states

According to the Tokyo Mou annual report and data in the database, author estimates data of flag states' inspected condition in 2012-2014, the results are shown in figure 4. Figure 4 is a statistical figure of initial inspection on more than 1000 ships, more than 1000 inspections were performed in the 15 member states, 7 of which were FOC countries: Antigua and Barbuda, Cyprus, Bahamas, Panama, Malta, Liberia and Marshall Islands. Among them, the ships registered in Panama took up 1/3 of the total inspected number.

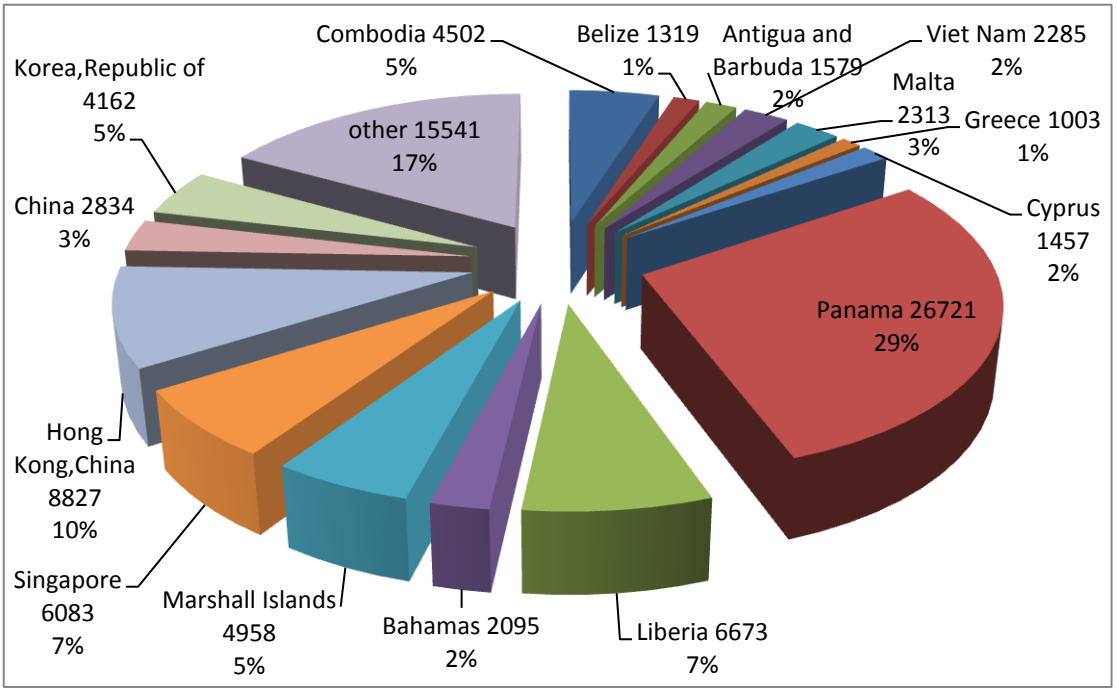

Figure 4 – Flag states individual ships inspected condition in 2012-2014
Source: Compiled by author

Figure 5 shows the flag states of which detention rate exceeded 10%, 3-year rolling average detention was 4.35% in 2012-2014, and a total of 15 flag states' detention rates were higher than 10%, which belong to the states with high detention risk.

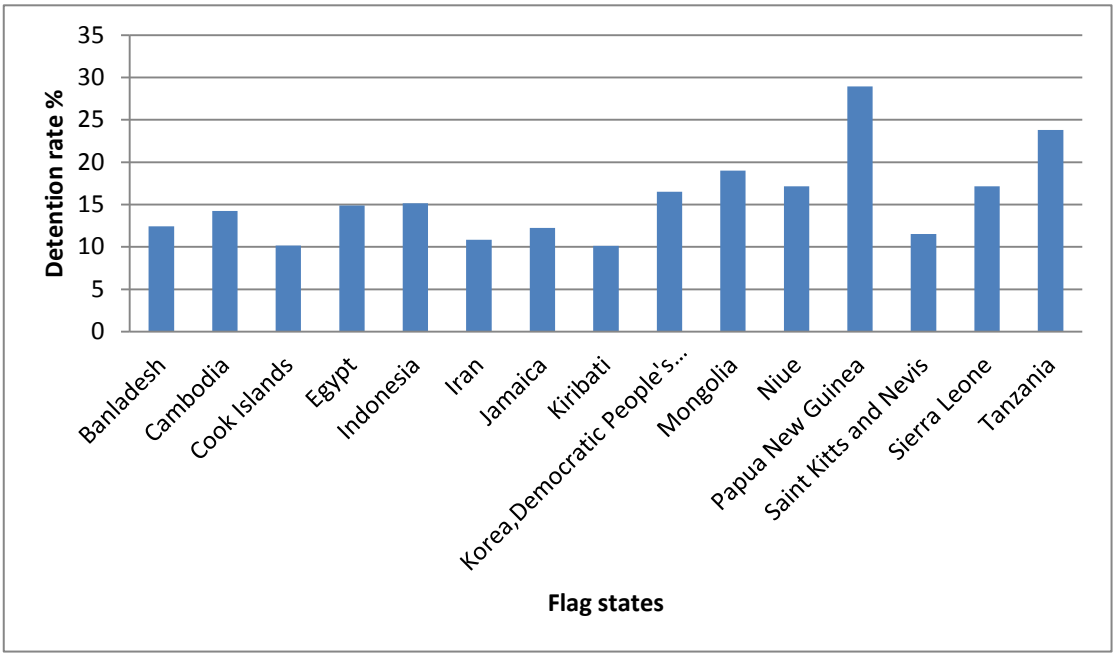

Figure 5 – Flag states detention percentage condition in 2012-2014
Source: Compiled by author

As seen from the overall trend, flag states' numbers in Tokyo Mou black list were constantly decreasing, while flag states' numbers in white list persistently increase in 2012-2014, indicating the favorable overall development situation. There were 12 flag states in 2014 Tokyo Mou black list, 3 states fewer than in 2013. The majority of ships that were divided into 'high risk' list in 2013 still appeared again in 2014, among which, safety condition of ships registered in Honduras, North Korea and Sierra Leone was not optimistic as before. The white list covered 33 countries in total, remarkably, the Vietnam rose to white list from black list(Tokyo Mou, 2014).

3.3 Analysis of detained deficiencies

3.3.1 Detention condition of 2014 Tokyo Mou

In 2014, average detention percentage was 3.96%. However, general dry cargo ship

and refrigerated cargo carrier were the two most detained ship types, accounting for 7.03% and 6.14% respectively, which were much more than the average detention percentage, as shown in figure 6. It is gratifying that the chemical tanker made up least detention percentage 1.27%, because the ship condition of chemical tanker was superior to other ship types, and marine equipments and crew quality aboard chemical tanker were also more sophisticated and satisfactory correspondingly.

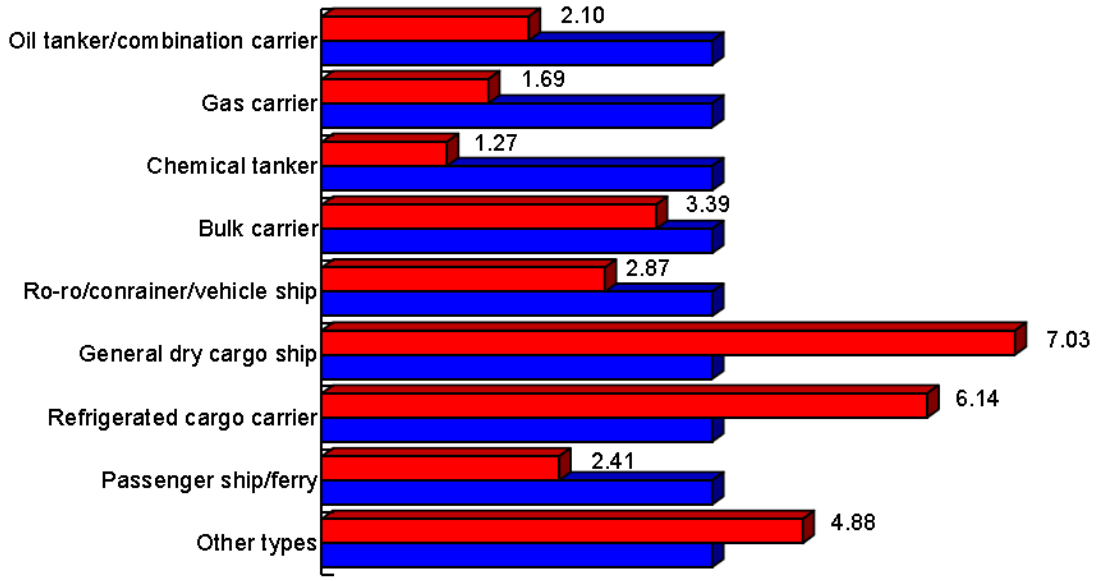

Figure 6 – Detention percentage per ship type in 2014 Tokyo Mou

Source: Annual report on PSC in the Asia-Pacific region 2014

With regard to the number of detainable deficiencies, it is worth noting that figure 7 shows that the detainable deficiencies concerning ISM item and fire safety were the most frequent, and sum of detainable number of ISM item (resources and personnel and shipboard operation) was 179 deficiencies, which illustrated that PSC authorities' inspection on validity of implementation of aboard SMS was more intensive. Detainable ISM deficiencies were mainly reflected in some aspects of ship's maintenance record, crew's acquaintance to SMS and training, shore-based supports, emergency drill and company's internal audit. What's more, fire safety has always

been the emphasis of PSC inspection, and sum of fire safety detention number was 188 deficiencies, which was reflected in fire-dampers and fire prevention structural integrity, and illustrates fire fighting and security on board desiderates reinforcement. In the next place, detainable deficiencies concerning life saving appliances such as lifeboats were also many, 136 detainable deficiencies.

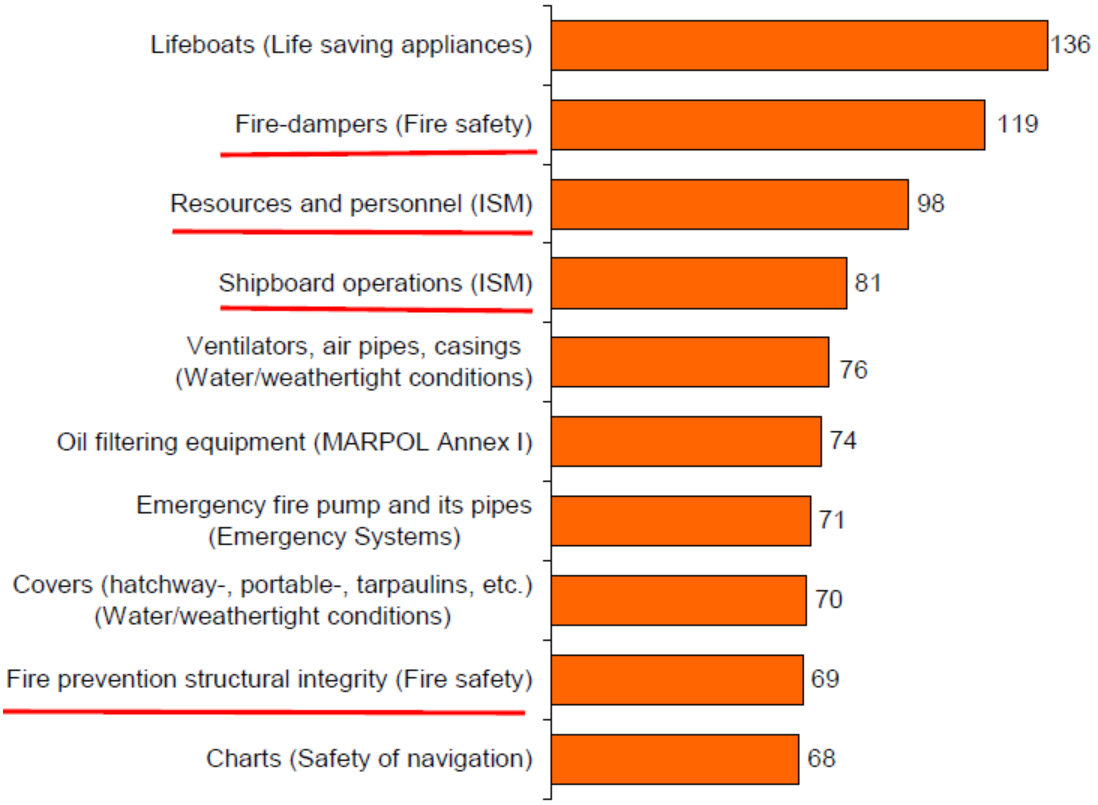

Figure 7 – Most frequent detainable deficiencies in 2014 Tokyo Mou

Source: Annual report on PSC in the Asia-Pacific region 2014

3.3.2 Contrastive analysis of detention condition for recent 3 years

Overall, there was a downward trend year by year in the number of detained ships in Tokyo Mou, 2012-2014. It proved that number of substandard ships was less and less. The number of detained ships in 2014 reduced to 1203 ships, from 1421 ships in

2012 to 1395 ships in 2013, as shown in figure 8.

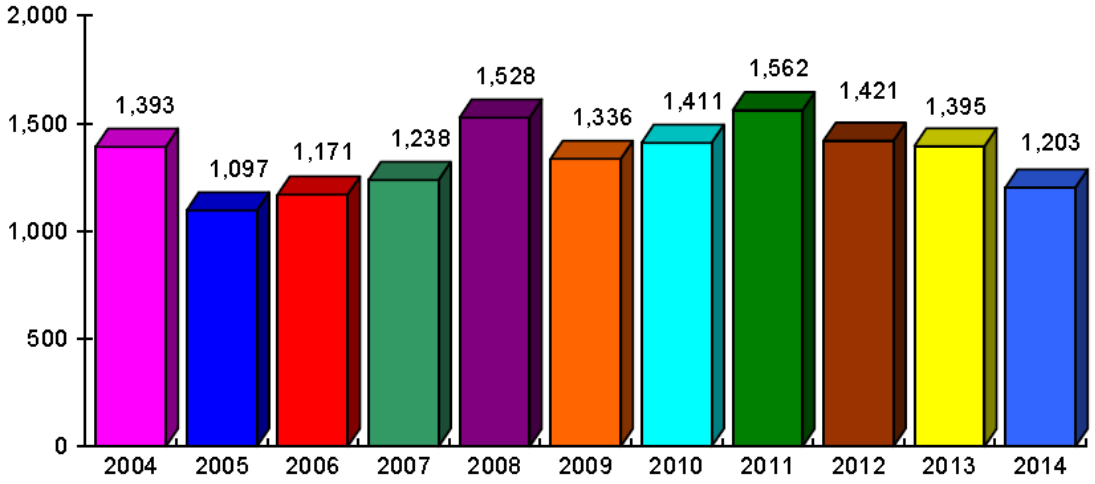

Figure 8 – Number of detained ships in Tokyo Mou, 2004-2014

Source: Annual report on PSC in the Asia-Pacific region 2014

Additionally, as shown in table 3, the number of detainable deficiencies was also smaller and smaller, especially for the three most detainable items: ISM, life saving appliances and fire safety, among which the detainable deficiencies of life saving appliances had the largest drop rate and reduced by 54 deficiencies from 190 deficiencies in 2013, which showed that shipping companies and managers on board paid more attention to life of crew and passengers and maintenance of lifeboat and its ancillary facilities. But on the other hand, compared with frequent detainable deficiencies in 2012 and 2014, the largest drop rate appeared in item of emergency system such as emergency fire pump and its pipes, which was 125 detainable deficiencies and then decreased by 54 detainable deficiencies in 2014.

Table 3 – Comparison of most frequent detainable deficiencies in Tokyo Mou 2012-2014

No.	Most frequent deficiencies	Year		
		2012	2013	2014
1	Lifeboats (Life saving appliances)	155	190	136
2	Fire-dampers (Fire safety)	155	120	119
3	Resources and personnel (ISM)	96	114	98
4	Shipboard operations (ISM)	96	76	81
5	Ventilators, air pipes, casings (Water/weathertight conditions)	74	76	76
6	Oil filtering equipment (MARPOL Annex I)	113	104	74
7	Emergency fire pump and its pipes (Emergency Systems)	125	99	71
8	Covers (hatchway-, portable-, tarpaulins, etc.) (Water/weathertight conditions)	61	68	70
9	Fire prevention structural integrity (Fire safety)	72	70	69
10	Charts (Safety of navigation)	50	78	68

Source: Annual report on PSC in the Asia-Pacific region 2014

The above information indicates that the Tokyo Mou is using this means of PSC to reduce substandard ships' operation in the Asia-Pacific region effectively, further to promote navigation safety and marine environmental protection.

Chapter 4 Current evaluation system of Flag state performance

At present, the majority of PSC memorandum organizations have established evaluation system of flag state's performance, and one of the most influential is flag state 'BGW' list regime adopted by Paris Mou and Tokyo Mou. The regime divides flag states into 'BGW' list according to different safety risks, namely different ship's detention rates, of flag state's fleet in recent 3 years.

4.1 Determination of 'black-grey-white' list

In the evaluation system of flag state 'BGW' list, performance of each flag state is calculated by standard formula, and the specific numerical value in the formula is determined uniformly by Paris Mou and Tokyo Mou. The 'BGW' list performance evaluation system introduces the concept of critical value, that is to say, defining $u_{\text{black-to-grey}}$ and $u_{\text{white-to-grey}}$ as allowable sum of detained ships' number of some flag state, if detained ships' number of some flag state exceeds $u_{\text{black-to-grey}}$, then this flag state would become 'Black list'; if the number of detained ships under $u_{\text{white-to-grey}}$, so the flag state would be in 'White list'; if the number is between $u_{\text{black-to-grey}}$ and $u_{\text{white-to-grey}}$, this state would become 'Gray list' flag state. Specific calculation formula is as follows: (Tokyo Mou, 2014, p54)

$$u_{\text{black-to-grey}} = N \times p + 0.5 + z\sqrt{N \times p \times （1 - p）} \qquad (1)$$

$$u_{\text{white-to-grey}} = N \times p - 0.5 - z\sqrt{N \times p \times （1 - p）} \qquad (2)$$

In formula (1) and (2), $u_{\text{black-to-grey}}$ is critical value from black list to gray list,

$u_{white\text{-}to\text{-}grey}$ is critical value from white list to gray list; N is sum of PSC inspection numbers of flag state's ships and dynamic; p is allowable detention rate limit, PSC organization generally defines p is 7%; z=1.645, it regards ship's detention condition as a standard normal distribution, and z is determined according to 95% probability in standard normal distribution table in statistics. Through the above formula, we only need to simply change inspection number N in the formula to inspection number of a flag state's ships, and calculate $u_{black\text{-}to\text{-}grey}$ and $u_{white\text{-}to\text{-}grey}$, afterwards, make a comparison with practical detention number of this flag state's ships, and then could estimate this flag state's position in 'BGW' list. The above formula only applies to the flag state that ships flying its flag are inspected more than 30 times in recent 3 years.

To reflect a flag state's performance more quantitatively, in addition to determination of 'BGW' list, Paris Mou and Tokyo Mou also introduce EF to describe a flag state's performance quantitatively. The greater EF value indicates this flag state's performance more disappointing; the smaller EF value indicates this flag state's performance more favorable. Corresponding EF value of critical value from black list to gray list is 1, corresponding EF value of critical value from white list to gray list is 0, as shown in figure 7. If all of the flag states' EF values are worked out, then we could conduct ranking by EF value(Walczak, 2014).

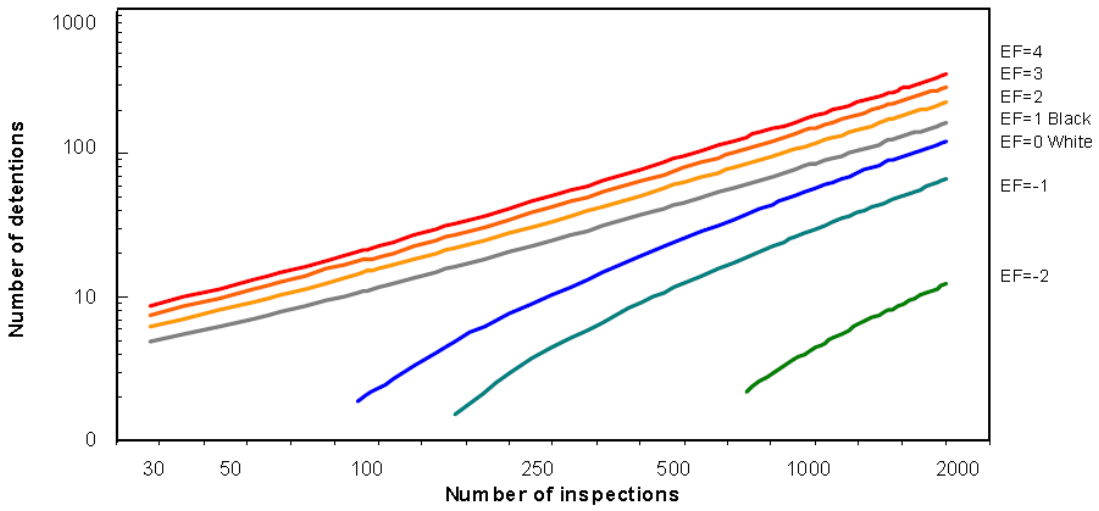

Figure 7 - Relation between the number of inspected ships and detentions
Source: Annual report on PSC in the Asia-Pacific region 2014

Calculation formula of EF value is as follows:(Wang et al, 2004)

EF value formula for flag states in black list:

$$\begin{cases} p' = 7\% + (EF - 1) \times 3\% \\ u' = N \times p' + 0.5 + z\sqrt{N \times p' \times （1 - p'）} \end{cases} \quad (3)$$

EF value formula for flag states in white list:

$$\begin{cases} p' = 7\% + (EF - 0) \times 3\% \\ u' = N \times p' - 0.5 - z\sqrt{N \times p' \times （1 - p'）} \end{cases} \quad (4)$$

EF value formula for flag states in gray list:

$$EF = \frac{u' - u_{white-to-grey}}{u_{black-to-grey} - u_{white-to-grey}} \quad (5)$$

In formula (3),(4)and(5), N is sum of PSC inspection numbers of flag state's ships, u' is practical detention number of ships flying its flag, p' is amendatory detention rate.

4.2 Examples for 'black-grey-white' list algorithm

This paper introduces computing method of 'BGW' list in detail based on data in 2014 Tokyo Mou annual report(Tokyo Mou, 2014).

4.2.1 Algorithm for Flag state in black list

Given PSC inspection of ships registered in Niue are 35 ships, practical detention is 6 ships, what is performance of flag state Niue and EF value?

$$u_{\text{black-to-grey}} = N \times p + 0.5 + z\sqrt{N \times p \times (1-p)}$$

$$= 35 \times 0.07 + 0.5 + 1.645\sqrt{35 \times 0.07 \times (1-0.07)} \approx 5.433$$

Niue's ships are detained 6 times actually that is greater than critical value black list to gray list $u_{\text{black-to-grey}}$, so Niue is 'Black list' flag state.

$$\begin{cases} p' = 7\% + (EF-1) \times 3\% \\ u' = N \times p' + 0.5 + z\sqrt{N \times p' \times (1-p')} \end{cases} \Rightarrow$$

$$\begin{cases} p' = 7\% + (EF-1) \times 3\% \\ 6 = 35 \times p' + 0.5 + 1.645\sqrt{35 \times p' \times (1-p')} \end{cases} \Rightarrow$$

$$p' \approx 0.0814, \quad EF \approx 1.38$$

4.2.2 Algorithm for Flag state in grey list

Given ships of Tuvalu are subject to 392 inspections of which 25 resulted in a detention, and what is performance of flag state Tuvalu and EF value?

$$u_{\text{black-to-grey}} = N \times p + 0.5 + z\sqrt{N \times p \times (1-p)}$$
$$= 392 \times 0.07 + 0.5 + 1.645\sqrt{392 \times 0.07 \times (1-0.07)} \approx 36.25$$

$$u_{\text{white-to-grey}} = N \times p - 0.5 - z\sqrt{N \times p \times （1-p）}$$
$$= 392 \times 0.07 - 0.5 - 1.645\sqrt{392 \times 0.07 \times (1-0.07)} \approx 18.63$$

Tuvalu's ships are detained 25 times practically that is between $u_{\text{black-to-grey}}$ and $u_{\text{white-to-grey}}$, so Tuvalu is 'Gray list' flag state.

$$EF = \frac{u' - u_{\text{white-to-grey}}}{u_{\text{black-to-grey}} - u_{\text{white-to-grey}}} = \frac{25 - 18.63}{36.25 - 18.63} \approx 0.36$$

4.2.3 Algorithm for Flag state in white list

Given ships of Viet Nam are subject to 2285 inspections of which 127 resulted in a detention, and what is performance of flag state Viet Nam and EF value?

$$u_{\text{white-to-grey}} = N \times p - 0.5 - z\sqrt{N \times p \times （1-p）}$$
$$= 2285 \times 0.07 - 0.5 - 1.645\sqrt{2285 \times 0.07 \times (1-0.07)} \approx 139.39$$

127 Viet Nam's ships are detained actually, lower than critical value white list to gray list $u_{white\text{-}to\text{-}grey}$, so Viet Nam is in 'White list'.

$$\begin{cases} p' = 7\% + (EF - 0) \times 3\% \\ u' = N \times p' - 0.5 - z\sqrt{N \times p' \times (1 - p')} \end{cases} \Rightarrow$$

$$\begin{cases} p' = 7\% + (EF - 0) \times 3\% \\ 127 = 2285 \times p' - 0.5 - 1.645\sqrt{2285 \times p' \times (1 - p')} \end{cases} \Rightarrow$$

$$p' \approx 0.0643, \quad EF \approx -0.19$$

4.3 Drawbacks of performance evaluation system of 'black-grey-white' list

4.3.1 Lack of data from other regional PSC organizations

According to Knapp et al(2008), in 2005, international navigation ships above 400GT accepted approximately 44000 PSC inspections, accounting for 47% of global international navigation fleets roughly. Among them, more than 50% ships had accepted PSC inspections by at least two regional memorandum organizations; 20% ships were inspected by at least three regional memorandum organizations. According to the flag state, ships registered in 33% of flag states had accepted inspections in at least six regional memorandum organizations; ships registered in 12% of flag states had accepted inspections in five regional memorandum organizations; ships registered in 9% of flag states had accepted inspections in four regional memorandum organizations; ships registered in 10% of flag states had accepted inspections in three regional memorandum organizations; ships registered in 11% of flag states had accepted inspections in two regional memorandum organizations; only ships registered in 6% of flag states had never accepted inspections in any regional

memorandum organization.

In current ‘BGW’ list performance evaluation system, each regional PSC organization does things in its own way, and only uses its own regional PSC data to evaluate every flag state’s performance, neglecting inspection data of other regional PSC organizations, of which obtained results are short of scientificity and fairness. Comparing ‘BGW’ lists of flag states performance released by Tokyo Mou and Paris Mou 2013 annual reports, we can see that there is a big contrast between the two, for example, Thailand was included in ‘Black list’ of Tokyo Mou, but in ‘White list’ of Paris Mou; Saint Vincent and the Grenadines were listed in ‘White list’ of Tokyo Mou, but in ‘Black list’ of Paris Mou.

4.3.2 Only application to large sample inspection data

The essence of current ‘BGW’ list performance evaluation system is adopting theory of standard normal distribution and confidence interval in statistics, according to confidence limit of detention rate of various flag states’ ships in PSC inspections, to conduct evaluation and ranking to flag states’ performance. In accordance with the central limit theorem, sample size is more than 30, which could be regarded as subjecting sample to standard normal distribution approximately. Therefore, existing ‘BGW’ list performance evaluation system only applies to large sample inspection data, namely ships flying flag state’s flag were subject to more than 30 inspections in recent 3 years. With regard to the flag states, ships flying their flag accepted less than 30 inspections in recent 3 years. The Tokyo Mou and Paris Mou leave them out of account, which is also explained specially in PSC annual report.

Scrutinizing PSC inspection data of the recent 3 years, we find that though ships that

register in individual flag state accepted less PSC inspections, their detention rate is very high, with a few of flag states' ships even reaching 100%, such as Cameroon(Paris Mou, 2013) and Bolivia(Tokyo Mou, 2014). It can be said that, Tokyo Mou and Paris Mou did not evaluate and rank these flag states' performance, and then these flag states escaped from punishment of 'Black list'. Individual ship owner may utilize the loophole to make flag-out decision and to register their own ships in these countries, thus to improve risk level of their own ships, which would affect interests of other flag states simultaneously.

4.3.3 Lack of maritime traffic accident factor

Maritime investigation and PSC inspection are the two important links in maritime safety chain, with the common ultimate goal of 'marine traffic safety and marine environmental protection' as well. Current 'BGW' list performance evaluation system is short of negative effects of maritime traffic accident factors, which may impact fairness and comprehensiveness of evaluation result. On 15th conference of FSI Sub-committee in IMO in June 2007, based on academic research achievement, the Turkish government put forward the risk assessment between marine accidents and PSC inspections in Europe, and advocated that: 'statistical data of PSC inspection should not be served as marine risk assessment standard directly; each regional PSC organization should not only establish harmonious marine risk assessment standard, in addition to PSC inspection factor, but also consider adding information including accident, ship owner, ship operator and so forth'(Turkish representative, 2007). A comparison of marine accident rate and PSC detention rate in Europe from 1999 to 2002 verified their viewpoints. Statistics showed that there is no proportional relation between accident rate and PSC detention rate, even though serious oil spill accidents happened, such as 'ERIKA' and 'PRESTIGE', the two

ships' flag states and classification societies had not appeared in Paris Mou's 'Black list' yet.

Chapter 5 Evaluation and verification of Flag state performance

5.1 Integration for inspection data from each regional PSC memorandum organization

Nowadays, Tokyo Mou and Paris Mou are using the same evaluation system of flag state's performance, and the difference is that both 'BGW' lists are based on respective database, therefore, it is necessary to integrate both of PSC database resources, and collectively carry out flag state's performance evaluation and issue. The evaluation result is applicable to both regional PSC memorandum organizations. Author integrates PSC data 2011-2013 of both Tokyo Mou and Paris Mou (2014 Paris Mou annual report not released yet),(Tokyo Mou, 2013)(Paris Mou, 2013) and calculates each flag state's performance according to 'BGW' list performance evaluation system introduced in Chapter 4, and the result is shown in table 2.

Table 2 –'BGW' list after data integration

Flag states	Inspection No. 2011-2013	Detention No. 2011-2013	$u_{black\text{-}to\text{-}grey}$	$u_{white\text{-}to\text{-}grey}$	EF	Flag state performance before data integration	
						Tokyo Mou	Paris Mou
Black list							
Tanzania	362	71	34		4.09	black	black
Korea, Democratic People's Republic	597	110	53		3.96	black	—
Papua New Guinea	39	10	6		3.65	black	—
Mongolia	414	72	38		3.48	black	—
Cambodia	5522	814	418		3.32	black	black
Sierra Leone	1119	173	93		3.24	black	black
Indonesia	535	79	48		2.78	black	—
Tonga	36	8	6		2.65	black	—

Dominica	144	23	16		2.43	grey	black
Honduras	48	9	7		2.15	—	black
Moldova	622	73	55		1.90	—	black
Bangladesh	142	20	15		1.89	black	—
Comoros	379	46	35		1.84	—	black
Togo	349	41	33		1.69	grey	black
Kiribati	632	68	55		1.61	black	—
Cook Islands	279	31	27		1.41	grey	black
Belize	1754	153	141		1.22	black	grey
Georgia	202	22	21		1.19	black	grey
Viet Nam	2310	194	182		1.16	black	—
Thailand	1007	86	84		1.05	black	white
Saint Kitts and Nevis	433	40	40		1.03	black	grey
Grey list							
Albania	117	13	13	3	0.98	—	grey
United Arab Emirates (UAE)	30	4	5	-1	0.84	—	—
Egypt	120	11	13	3	0.76	grey	grey
Tuvalu	446	35	41	22	0.70	grey	grey
Libyan Arab Jamahiriya	54	5	7	0	0.67	—	grey
Lebanon	81	7	10	1	0.66	—	grey
Algeria	82	7	10	1	0.65	—	grey
Kuwait	67	5	9	1	0.54	grey	—
Saint Vincent and the Grenadines	1577	111	128	93	0.52	white	black
Ukraine	240	17	24	10	0.51	—	grey
Jamaica	44	3	6	0	0.49	grey	—
Morocco	65	4	8	1	0.43	—	grey
Israel	37	2	6	0	0.40	—	—
Syrian Arab Republic	42	2	6	0	0.35	—	grey
Qatar	36	1	6	0	0.25	—	—
Bulgaria	59	2	8	0	0.21	—	grey
Portugal	388	22	36	18	0.21	—	grey
Sri Lanka	43	1	6	0	0.19	—	—
Curacao	334	18	32	15	0.17	grey	grey
Uruguay	237	12	24	10	0.17	—	—
Tunisia	51	1	7	0	0.13	—	grey
India	431	23	39	21	0.11	grey	grey

Philippines	820	47	70	45	0.08	grey	white
White list							
Spain	217	8	22	9	-0.10	—	white
Taiwan, China	309	13	30	14	-0.10	white	—
Poland	162	5	17	5	-0.13	—	white
Lithuania	182	6	19	7	-0.13	—	white
Switzerland	170	5	18	6	-0.23	grey	white
Iran	132	3	15	4	-0.31	grey	white
Luxemburg	242	8	24	10	-0.32	grey	white
Antigua and Barbuda	5368	288	407	345	-0.37	grey	white
Vanuatu	342	12	32	16	-0.43	white	grey
Faroe Islands, DK	241	7	24	10	-0.49	—	white
Ireland	93	1	11	2	-0.50	—	white
Malaysia	838	34	71	46	-0.53	white	grey
Turkey	1842	78	147	110	-0.63	grey	white
Kazakhstan	69	0	9	1	-0.64	—	white
Barbados	419	13	38	20	-0.68	grey	white
Panama	33047	1550	2390	2236	-0.70	white	white
Russian Federation	2258	90	179	138	-0.75	white	white
Estonia	74	0	9	1	-0.75	—	white
Latvia	75	0	9	1	-0.77	—	white
Cyprus	3402	127	263	213	-0.89	white	white
Malta	6625	251	498	429	-0.93	white	white
United States	436	10	40	21	-1.02	white	white
Gibraltar (UK)	1071	31	89	61	-1.03	grey	white
Liberia	10524	343	780	693	-1.15	white	white
Cayman Islands (UK)	662	15	58	35	-1.16	white	white
Bermuda (UK)	480	9	43	24	-1.22	white	white
Netherlands	3557	98	275	223	-1.25	white	white
Belgium	338	5	32	15	-1.27	grey	white
Greece	1957	49	156	118	-1.27	white	white
Marshall Islands	6779	190	510	439	-1.28	white	white
Germany	1622	38	131	96	-1.31	white	white
Italy	1732	40	139	103	-1.33	white	white
Denmark	1512	31	123	89	-1.41	white	white
Bahamas	4513	106	345	287	-1.41	white	white
United Kingdom (UK)	2318	50	183	142	-1.42	white	white

Saudi Arabia	133	0	15	4	-1.44	white	white
Japan	555	8	49	28	-1.45	white	white
Isle of Man (UK)	1170	20	97	67	-1.50	white	white
Finland	425	4	39	21	-1.59	—	white
Croatia	234	1	23	9	-1.59	white	white
Sweden	550	6	49	28	-1.60	grey	white
Norway	2246	37	178	137	-1.61	white	white
Singapore	7001	114	526	454	-1.70	white	white
Hong Kong, China	9753	117	725	641	-1.87	white	white
France	409	1	38	20	-1.91	white	white
China	2820	19	220	175	-2.00	white	white
Korea, Republic of	4106	26	315	260	-2.04	white	white

Source: Compiled by author

On basis of Tokyo Mou 2013 annual report, the number of flag states in black list was 15, the number of grey list flag states was 19, 30 countries were listed in white list(Tokyo Mou, 2013). On the other hand, in Paris Mou 2013 annual report, the number of flag states in black list was 46, in grey list was 19, and 30 countries were in white list(Paris Mou, 2013). Trough integration of PSC data of both Tokyo Mou and Paris Mou for the recent 3 years, and utilization of the same 'BGW' list evaluation, the evaluation result shows that the number of flag states in black list is 21, 23 countries are in grey list, and the number of flag states in white list is 47. Additionally, some flag states' performance also change, for example, Saint Vincent and the Grenadines was listed in 'White list' in Tokyo Mou and 'Black list' in Paris Mou originally, but via data integration, it is listed in 'Grey list'; Thailand was included in 'Black list' in Tokyo Mou and 'White list' in Paris Mou, through data integration, Thailand is included in 'Black list'.

5.2 Analysis on Flag states' performance based on Bayes theorem

As mentioned above, the 'BGW' list regime only applies to the flag state that ships

flying its flag are subject to more than 30 inspections in recent 3 years. It is not suitable for flag state that was seldom inspected. Therefore, current flag state's performance evaluation system has limitations. So how to evaluate the flag state that ships flying its flag are subject to less than 30 inspections? This chapter introduces the concept of 'weighted detention rate' according to Bayes theorem, in order to reflect flag state's performance more objectively and actually.

The Bayesian inference is a kind of decision statistical approach applicable to uncertain conditions. Bayesian inference amends original judgement through collected historical information, constantly makes judged results tend to the reality. Its fundamental method is to synthesize prior information related to unknown parameter and sample information, then work out posterior information according to Bayes theorem, afterwards to deduce this unknown parameter according to the posterior information(Cao, 2012). Specifically, when less historical information cannot serve as statistics or comparative objects, we could set an estimated value (prior probability) as 'weight' adding to evaluation value. When collected historical data accumulate, namely the historical data increasingly reflect authentic assessment, then proportion of the weight would be increasingly small. As we can see, introduction of Bayes theorem to solve limitation of evaluating flag state's performance, while less historical inspection data mentioned in this chapter, is appropriate.

Assuming one flag state (Flag Ai), PSC inspection number of the ships flying its flag in recent 3 years is psc（Ai）, detention rate is pro（Ai）, average inspected number of each flag state is Avgpsc, average detention rate is Avgpro, pro（Ai）and Avgpro are prior probabilities. Then the weighted detention rate W(Ai) of Flag Ai is

$$W(A_i) = \frac{psc(A_i)}{psc(A_i)+Avgpsc} \times pro(A_i) + \frac{Avgpsc}{psc(A_i)+Avgpsc} \times Avgpro \quad (6)$$

Weighting factor 1： $\frac{psc(A_i)}{psc(A_i)+Avgpsc}$+Weighting factor 2： $\frac{Avgpsc}{psc(A_i)+Avgpsc}$=1

As we can see from formula (6), because PSC inspection number of each flag state's ships adds the element of average inspection number Avgpsc, so that all flag states lie on a basis of similar historical inspection record, and assume them have mean level.

When PSC inspection number of some flag state's ships in recent 3 years psc（Ai）＞Avgpsc, the weighting factor 1 is bigger, then function of detention rate pro（Ai）in the weighted detention rate W（Ai） is bigger; when psc（Ai）＜Avgpsc, the weighting factor 2 is bigger, then average detention rate Avgpro has bigger function in the weighted detention rate W（Ai）.

Assuming Flag Ai, its ships' detention number in PSC inspection recent 3 years is detain（Ai）, then

$$detain（A_i） = psc(A_i) \times pro(A_i) \quad (7)$$

Assuming Tokyo Mou conducts evaluation on n flag states' performance, the formula (6) could be unfolded and converted into more general form:

$$W(A_i) = \frac{detain(A_i)+\sum_{i=1}^{n} detain(A_i)/n}{psc(A_i)+\sum_{i=1}^{n} psc(A_i)/n} \quad (8)$$

Tokyo Mou could utilize these PSC inspection data of flag state's ships to figure out

average inspection number Avgpsc and average detention number Avgdetain, further to work out their weighted detention rate.

$$\text{Avgpsc} = \sum_{i=1}^{n} \text{psc}(A_i)/n \quad (9)$$

$$\text{Avgdetain} = \sum_{i=1}^{n} \text{detain}(A_i)/n \quad (10)$$

The formula (8) could be further simplified as

$$W(A_i) = \frac{\text{detain}(A_i)+\text{Avgdetain}}{\text{psc}(A_i)+\text{Avgpsc}} \quad (11)$$

This chapter only evaluates flag states of which ships are subject to less than 30 PSC inspections in 2012-2014 in Tokyo Mou, according to Bayes theorem, works out weighted detention rate of each flag state, and ranks from low to high. Lower weighted detention rate indicates better flag state's performance; higher weighted detention rate manifests worse flag state's performance. Result of weighted detention rate is shown in table 3.

Table 3 – Tokyo Mou Flag states' performance based on Bayes theorem 2012-2014

Flag states	Inspection No.	Detention No.	Detention rate	Weighted detention rate
Australia	14	0	0.00%	2.78%
Pakistan	11	0	0.00%	3.28%
Palau	9	0	0.00%	3.73%
Ecuador	6	0	0.00%	4.68%
Falkland Islands (UK)	6	0	0.00%	4.68%
Solomon Islands	6	0	0.00%	4.68%
Maldives	5	0	0.00%	5.11%
New Zealand	5	0	0.00%	5.11%
Chile	4	0	0.00%	5.64%

Jordan	3	0	0.00%	6.28%
Colombia	2	0	0.00%	7.09%
Nigeria	2	0	0.00%	7.09%
Ethiopia	14	1	7.14%	7.84%
Canada	1	0	0.00%	8.14%
Fiji	1	0	0.00%	8.14%
Gambia	1	0	0.00%	8.14%
Iceland	1	0	0.00%	8.14%
Lao,People's Democratic Republic	1	0	0.00%	8.14%
Montenegro	1	0	0.00%	8.14%
Bahrain	10	1	10.00%	9.84%
Samoa	9	1	11.11%	10.50%
Brunei Darussalam	6	1	16.67%	13.18%
Equatorial Guinea	6	1	16.67%	13.18%
Argentina	4	1	25.00%	15.88%
Peru	16	3	18.75%	16.31%
Myanmar	14	3	21.43%	17.97%
Brazil	7	2	28.57%	19.98%
Bolivia	1	1	100.00%	22.93%
Mauritius	1	1	100.00%	22.93%

Source: Compiled by author

5.3 Consideration of maritime traffic accident factor

Next, author will apply adding maritime traffic accident factor to evaluate flag state's performance. According to Bayes theorem and formula (11), weighted detention rate W1(Ai) of Flag Ai is

$$W1(A_i) = \frac{detain(A_i)+Avgdetain}{psc(A_i)+Avgpsc} \quad (12)$$

Assuming Flag state Ai, its registered ships number is reg（Ai）, number of accidents over significant level in recent 3 years is acc（Ai）, average number of ships

registered in each flag state is Avgreg, average number of accidents over significant level in recent 3 years is Avgacc. Then the weighted detention rate W2(Ai) of Flag Ai is

$$W2(A_i) = \frac{acc(A_i)+Avgacc}{reg\ (A_i)+Avgreg} \quad (13)$$

Overall consideration of PSC inspection and maritime traffic accident, author proposed evaluation formula of flag state's performance is as follows:

$$W(A_i) = k_1 \cdot W1(A_i) + k_2 \cdot W2(A_i) = k_1 \cdot \frac{detain(A_i)+Avgdetain}{psc(A_i)+Avgpsc} + k_2 \cdot \frac{acc(A_i)+Avgacc}{reg\ (A_i)+Avgreg} \quad (14)$$

K1 and k2 are weighting factors of PSC and maritime accident respectively, which are determined by PSC memorandum organizations themselves.

Because data of major grade accidents and very serious grade accidents that occurred onboard flag states' ships for recent 3 years are not available, this paper could not conduct verification by this method.

5.4 Analysis of evaluation index

Through establishment and calculation of evaluation index, the results indicate that inspected ships' three indicators, inspection numbers, detention numbers and accident numbers, directly affect ships' safety conditions, and high detention rate is the direct factor of taking down overall evaluation result. However, some factors of marine operation management, such as differences in flag states' performance,

information openness of port state, R.O.'s service quality, safety management situation of shipping companies and so forth, are the immediate reasons why ships' detention rate is staying at a high level.

(1)Along with constant evolution of various regulations and codes developed by IMO, we can see a obvious trend of IMO - strengthening flag states' obligations of supervising ships flying their flag: constant conduct of ISM nationalization brings shipping companies into the jurisdiction of flag states; establishment of ship's replacement mechanism makes flag states' jurisdiction extend to shipyard; and the ISPS Code significantly affects port's business income, and so on. However, a few flag states do not really care about security and environmental protection required by conventions, but how to firstly cater to their domestic political and economic interests. Thus the gap in flag states' performance is produced. Because of different politics, economy, technology and culture, there are enormous gaps in performing conventions in different countries, and the imbalance of development also results in wide difference in execution within the same country.

(2)At present, majority of PSC working modes come down to assault inspection, and each inspection generally consumes several hours or even longer time, which certainly affects marine daily work, especially for crew rest; in the next place, inspection content is not open effectively. Currently most of port states have not formulated relevant specification to guide PSCO to inform crew of inspection content, therefore, inspection content and inspection sequence are decided by PSCO's experience fundamentally, and whether to inform crew of inspection plan is also decided by PSCO, which would make an influence on inspection efficiency and degree of cooperation between crew and PSCO. In addition, the inspection results that are not open effectively limits the guiding role of PSC.

(3)Shipping company is the first responsible role for marine safety management, and the influence of specific circumstance of its management level on ship security is very significant. Therefore, IMO developed ISM Code and started to comprehensively implement on contracting states on July 1, 2002, and numbers of contracting states also formulated ship safety management code and carried out popularizing and implementing at home. At present, various worldwide PSC memorandum organizations bring shipping companies' safety management condition as significant factor into marine security evaluation, so this indicator is also one of target factors of marine security evaluation.

(4)Survey quality and service quality of R.O. are among the factors of marine security evaluation. Some R.O. only care about statutory survey, ignoring service quality , and fail to timely communicate and cooperate with local PSC authorities. When ships are subject to PSC inspections or suffer detention in foreign ports, their R.O. with nonfeasance cannot address any problem, which is also one of the reasons why ships have high detention rate. Additionally, a few R.O. fail to give full play to their technological superiority, to provide technical support and protection for serving shipping companies and ships.

(5)Executive condition of SMS on board directly affects familiarity with ships, ship's manipulation and maintenance of mechanical equipments, simultaneously reflects ship's operation management level. As we can see from figure 7, status quo of implementing SMS is unoptimistic now. Marine safety management needs each link of the whole management chain including flag state, R.O., port state, etc., to play a role, among them functions of DP and master are vital. Management motivation, effective monitor and continuous improvement of DP and master constitute a good

barrier for marine security and anti-pollution. Whether safety inspection or system audit, actually it is evaluating responsible personnel's working attitude, job performance and management ability. In any case, structuring a sound crew team is priority among priorities in marine safety management.

Chapter 6 Measures for promoting Flag state performance

Flag state's performance reflects safety management level of ships owned by one country and competitiveness of international navigation fleet, meanwhile concerns reputation and image of flag state. Even though PSC data of Tokyo Mou show favorable situation with the decreasing number of substandard ships in recent years, we cannot relax. Various parties including flag state's authorities, port state, R.O., shipping companies, etc. should perform obligations seriously, actually safeguard ship's navigation safety and marine environment in Asia-Pacific region.

6.1 Flag states' measures

6.1.1 Implementation of quality management system of ship registration

In order to make fleet develop normally and safeguard maritime security, flag states need to establish a whole set of new efficient safety management mechanisms complied with modern management and control theory, and establish ship registration QMS of flag state. For example, Hong Kong Marine Department started to carry out FSQCS on Apirl 1,1999, rapidly take flag state's reaction to registered ships anywhere in the world, and effectively enhance its fleet's quality(Yu, 2009). Each maritime authority should not only establish shipping quality control before registration, but also found supervisory control mechanism of fleet quality after registration. Specifically, authority should not only collect fleet's safety information at home, but also maintain sufficient communication with other port state organizations, gather and analyze fleet's security information abroad (detention, accident, pollution accident and departure information), and establish ganged supervision mechanism combing ship supervision and company audit, further to form

management joint-force, as well as revoke registration permit of home port for unsafe substandard ships on occasion.

6.1.2 Rational utilization of international rules builds level playing field

The primary principle of international law is the national sovereign equality principle, which means all nations are completely equal in the international legal relation, without jurisdiction and control over each other(Janis, 2015). Reciprocity principle is derived from sovereign equality principle, and PSC is port state's right endowed by conventions to supervise and inspect foreign ships, which deserves various countries' esteem.

However, PSC inspection is often subject to restraint and influence of political factors, and some detentions are resulted by non-technical factors. For example, in the 1990s, Japanese and Korean maritime authorities strengthened PSC inspection intensity on Chinese international navigation ships, and detained a number of Chinese ships, which seriously damaged interests of Chinese fleet, simultaneously impacted flag state's performance of China. In order to create fair competitive context for Chinese fleet, based on reciprocity principle, Chinese maritime authorities also intensified PSC inspection on above countries' ships, and detained a few of Japanese and Korean ships. Realizing gravity of the issue, the two countries had to initiatively negotiate and communicate with China, ultimately changed from confrontation to cooperation(Chen, 2007).

In order to build fair market circumstance for flag state's fleet, flag state's authority should deepen international exchange and cooperation with other port states, promote understanding and mutual trust, prevent international navigation ships flying its flag

being detained improperly abroad(Guo, 2006).

6.1.3 Enhancement of service functions and service awareness

In spite of flag states' responsibility restricted to ship registration, inspection, quality management, crew training and so forth, nevertheless, service function and service awareness of flag states' authority shall be reinforced. Establishment of service concept is foundation of the shipping industry, which is the same philosophy in government sectors, one critical element derived from modern public management. Once service concept is set up, responsibility would be performed more easily, and conventions are easier to be accepted. In terms of flag states' authorities, their objective is to satisfy shipping industry and its various surroundings. With respect to service concept, there is no distinction among different countries, therefore, contradiction in service doesn't exist between public sector and individual sector. 'Helping ship owners to realize their business objective' should be motto that flag states believe in nowadays.

6.2 Port states should raise information openness

At present, PSC work patterns of some countries still belong to surprise inspection, and this kind of inspection mode brings about certain influence on shipping schedule, crew rest and inspection efficiency, and inspection result is relatively closed. Therefore, port state should explore and practice open PSC mechanism which is different from the current surprise inspection mode generally adopted worldwide, and is a kind of ship safety inspection mode with more open information, closer cooperation between both sides, as well as broader participation scope(Li, 2013).

It mainly includes three aspects. The first one is opening inspection plan. After targeting a ship, PSCO could notify the master, shipping company or agency that the ship would be accepted PSC inspection. The crew could prepare beforehand, or conduct self inspection on key equipments, or arrange work and rest schedule in advance, and then could cooperate with PSCO's inspection effectively and rapidly, which ensure favoring shipping operation and effective crew rest. The second one is opening inspection content. PSCO could clear up an inspection list in advance and inform the crew to make full preparation, and to carry out self inspection according to the inspection list ahead of schedule. The third one is opening inspection result. PSC authority could open typical inspection deficiencies on the premise of protecting privacy or other legitimate interest of concerned ships and shipping company. Maritime authority can propagandize safety philosophy, deficiencies and accident analysis to shipping companies and crew through rapid network exchange platform, create safety culture to reduce accident occurrence via both guidance and communication.

6.3 R.O. should accomplish technical support and service

In addition to statutory survey of ships, R.O. should take full advantage of embranchment overseas, communicate with local PSC authority and promote trust and cooperation. When flag states' ships encounter problems during PSC inspection, the R.O. could timely communicate and eliminate the problems in the bud, and prevent problems upgrading to detention level. While receiving information concerning ship detention, R.O. should organize personnel to verify correctness of the deficiencies as soon as possible, and notify local embranchment to designate surveyor embarkation, and estimate whether the deficiencies comply with the ship's actual situation or not. As to determinate deficiencies, surveyor should guide and

assist vessel to correct as soon as possible; as to objectionable deficiencies, surveyor should obtain scene evidence and assist vessel to conduct reasonable defense, avoiding event escalation. In the meantime, R.O. should exert technological superiority, provide technical support and service for shipping company, timely convey new effective convention, regulation and technical specification to shipping company, guide shipping company and ships to perform effectively; offer special training service on convention, regulation and technical specification according to actual demand of shipping company.

6.4 Shipping companies should positively react

2014 Tokyo Mou NIR firstly introduced corporate performance as one of parameters of assessing ship risks. Therefore, shipping companies should grasp their ships' risk level in time through Tokyo Mou database, and reinforce the management and shore-based support for ships having high risk level, hire well-qualified crew to reduce ships' risk. Additionally, shipping companies should also arrange routes reasonably, avoid arranging ships with high risk to strict inspection ports, or make full preparation, conduct self inspection periodically to promote safety management awareness.

In addition, shipping companies should sufficiently trust the flag state's authority, R.O. and the port state's authority. In case of deficiencies, they should timely report to the relevant party, seeking positive support or understanding. They should not conceal or deal with significant problem affecting navigation safety without authorization(Mei, 2011). Facing detention risk, their own ships should reasonably defend, asking for PSCO's explanation for detainable deficiencies and relevant conventions. Under allowable condition, they should, to the best of their ability,

collect evidence through photograph or video, simultaneously immediately report site conditions to shipping company or flag state.

6.5 Personnel being responsible for marine management and operation should execute ISM Code strictly

Modern shipping companies have established normative SMS. Master should ensure each department aboard strictly implement SMS's various requirements especially for marine maintenance, and make records. Before port calling, master should also carry out self inspection in advance, so as to find shortcomings or existing deficiencies according to key point of local PSC inspection prepared, then organize personnel to repair or correct as soon as possible; once failing to solve, the relevant responsible should immediately adopt emergent alternative measure according to SMS documents; meanwhile, timely report conditions to company to seek shore-based support, so as to rise to initiative from passiveness in PSC inspection, to obtain PSCO's recognition(Zhang, 2007).

Chapter 7 Conclusion

This research paper mainly analyzes ship security based on PSC data of Tokyo Mou in 2012-2014, including Tokyo Mou 2014 annual report and evaluation system of flag state's performance. Flag state's performance has a significant influence on the interest of fleet flying its flag, and truly reflects ship security. Through analysis, this paper sets forth relevant concepts of flag states' performance and PSC, as well as the relationship between flag states' performance and PSC in terms of navigation safety safeguard, and analyzes PSC inspection condition of Tokyo Mou in 2012-2014 in detail, including comparative analysis of inspection condition in the recent 3 years, member state's inspection and inspected condition of flag states. After that, this paper particularly introduces 'BGW' list evaluation system of flag states' performance, analyzes drawbacks of 'BGW' list and objectively evaluates flag state's performance by integrating PSC data of each regional memorandum organizations, Bayes theorem and adding maritime traffic accident factors, as well as data verification. Ultimately, in accordance with current situation of flag states and PSC, this paper puts forward improved measures for flag states' performance from other perspectives, such as implementation of flag state's ship registration QMS, openness of port state's information, execution of ISM code for shipping company and operational personnel aboard, and so forth.

Since otherness exists in PSC inspections in various regions and data are hard to integrate, this paper has done statistic analysis only by means of data of Tokyo Mou and Paris Mou, which is not comprehensive. With implementation of uniform PSC inspection regime in future, flag state's marine safety management condition would be more accurately evaluated taking advantage of global statistics.

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The Tokyo Mou web site gives further information on organizations: http://www.tokyo-mou.org/organization

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